Research on Recreational Boat Speed Measuring Devices

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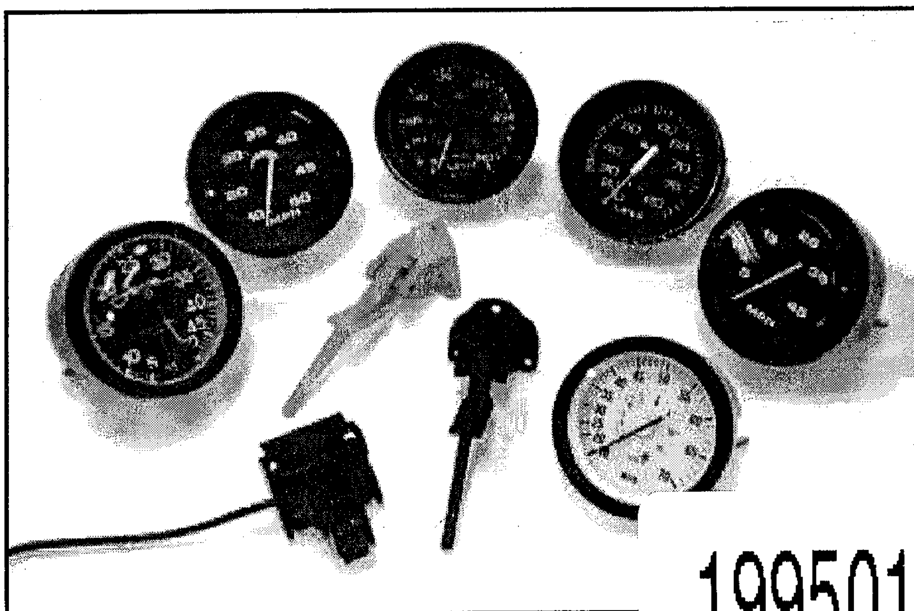

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Acknowledgments

This project is the result of the efforts, contributions and talents of many individuals, companies and agencies. It is not possible to list all those that contributed, but special thanks is given in these paragraphs to those who were especially important to the success of this project.

Special thanks goes to the US Coast Guard for their interest in supporting boating safety activities and their support in the area of speed measuring devices research.

Thanks to all of the boat manufacturers and manufacturers of after-market speed measuring devices who provided invaluable information and comments through the survey and generously donated the speed measuring device kits needed for testing.

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To the countless individuals, companies and others not mentioned above who contributed, please know that we truly appreciate your contributions to this research.

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DISCLAIMER

ABSTRACT

This report is the result of two years of research and testing to determine the accuracy of speed measuring devices available on recreational boats ranging from 12 to 26 ft in length. The purpose and goals of the project are outlined in Chapter 1.

Chapter 2 presents the results of a survey sent to recreational boat manufacturers selected at random, and after-market kit manufacturers. The purpose of the survey was to provide an estimate of:

- The number of boats that are purchased without factory installed speed measuring devices.
- The types of speed measuring devices that are available and most commonly used.
- The types of speed-measuring devices that are available as after-market kits.
- Determine the accuracy and reliability of the types most commonly available.
- Determine mounting locations for sensors to provide a high degree of accuracy.

Chapter 3 examines testing performed in the laboratory intended to simulate the actual environment the speed measuring devices would be exposed to on a recreational boat and to provide a calibration for each unit. Each speed measuring device was subjected to water flow of various calibrated velocities and compared to the velocity reading on the speed-measuring device's speed indicator. The results of this laboratory testing determined which speed measuring devices were most accurate. These devices would be used for field testing.

Chapter 4 investigates testing which was performed in the field using six of the most accurate speed measuring devices as a result of the laboratory testing as described in chapter 3. The purpose of the field testing was to determine which type of speed measuring devices were the most accurate when compared to the speed measured by RADAR and by a fixed distance timing method. Several different mounting locations were used to determine which hull location was most accurate.

Chapter 5 reveals the overall results of this project and gives recommendations as to which types of speed-measuring devices and at what location are most accurate on recreational boats.

CHAPTER 1

INTRODUCTION

1.0 Problem

Recreational boats with higher horsepower engines are becoming more common and available. At the same time, our water ways are becoming more congested. To provide an acceptable level of safety for the boating public, jurisdictions are becoming more interested in establishing speed limits for boats. Before safe speed limits can be established on our waterways, the accuracy of the speed measuring devices mounted on recreational boats must be determined to reveal how accountable the boat operator is for his/her boat's speed.

1.1 Scope

The scope of this project will be directed toward recreational boats ranging primarily from 12 to 26 feet in length. The objectives of this project will focus on the following tasks:

- Conduct a random survey of both boat and after-market speed measuring device manufacturers.
- Estimate the number of boats in the survey between 12 and 26 ft that are purchased without factory installed speed measuring devices.
- Determine what types of speed measuring devices are available and most commonly used on boats between 12 and 26 ft.
- Establish what types of speed measuring devices are available as after-market kits.
- Determine the accuracy and reliability of the types most commonly available and most commonly used devices.
- Resolve a mounting location for a sensor to insure a high degree of accuracy.

Based on the results of the survey, several speed measuring device kits will be tested in a laboratory environment to determine which speed measuring devices are most accurate out of the group. The most accurate of these speed measuring devices will be tested on boats in the field to determine which speed measuring devices are most accurate and at what mounting locations they are most accurate.

1.3 Purpose

The purpose of this project is to determine the accuracy of speed measuring devices, both factory installed and after-market kits, on recreational boats between 12 and 26 ft.

1.4 Goals and Objectives

Some specific goals and objectives of this investigation are outlined below.

Goal No. 1:

Conduct a random survey of boat and after-market speed measuring device manufacturers, collect and analyze the data, and begin laboratory testing using the speed measuring devices based on the survey results

Goal No. 2:

Compare the accuracy of the speed measuring devices to a calibrated water flow simulated in a laboratory environment and determine the most accurate speed measuring devices out of the group tested.

Goal No. 3:

Test the most accurate speed measuring devices as determined in goal no. 2 on actual boats in the field. Determine which devices and which boat mounting locations are most accurate.

Goal No. 4:

Analyze all of the research and test data and make recommendations based on these results as to which speed measuring devices are most accurate and at which mounting location they are most accurate.

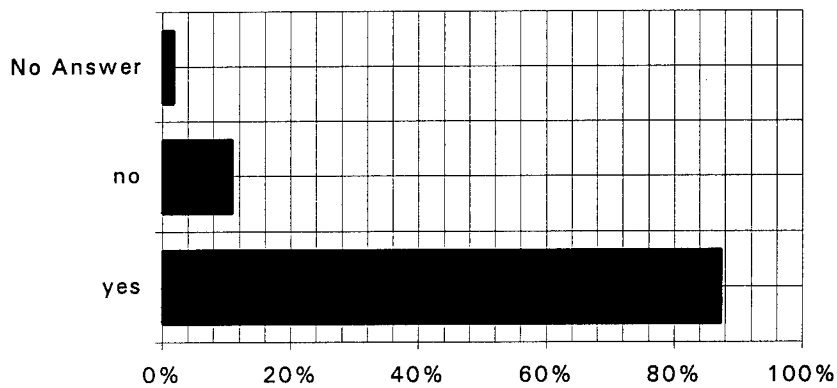
CHAPTER 2

SURVEY

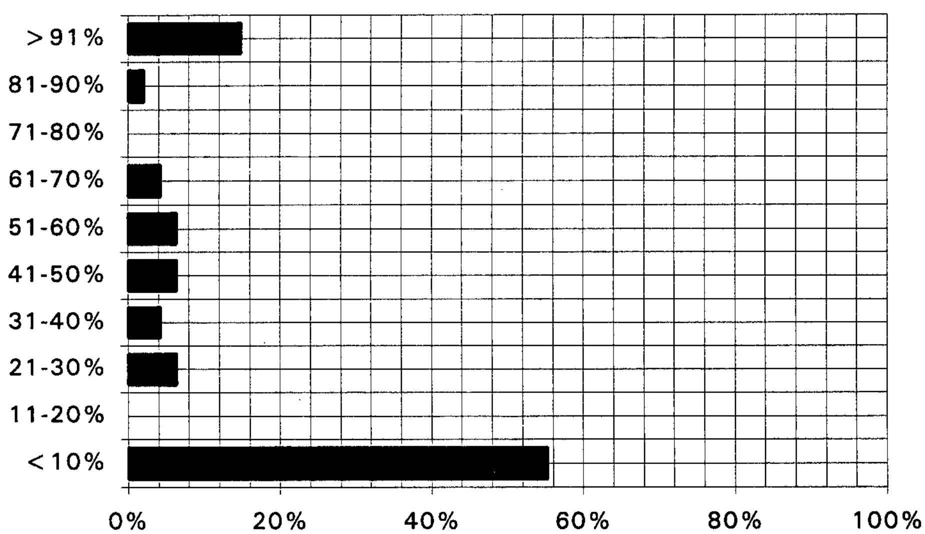
2.0 Survey Questions and Responses

Two hundred and twenty two surveys consisting of 15 questions were sent to various boat manufacturers and various manufacturers of after-market speed measuring devices of which 56 were returned. The survey questions posed to the manufactures and their responses were as follows (Note that the Y-axis contains data which is outlined in each question and the X-axis represents the percentage of total responses). For example, the possible answers to questions no. 1 are "No Answer", "No" and "Yes". Two percent did not answer the question, nine percent answered "No" and 87% answered "Yes".

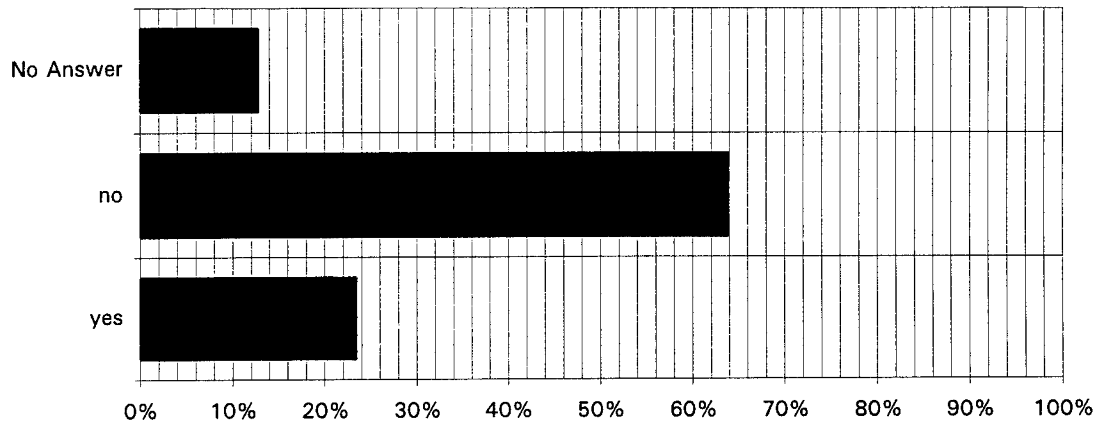
1. Do you manufacture propulsion-powered recreation boats ranging from 12 to 26 ft?



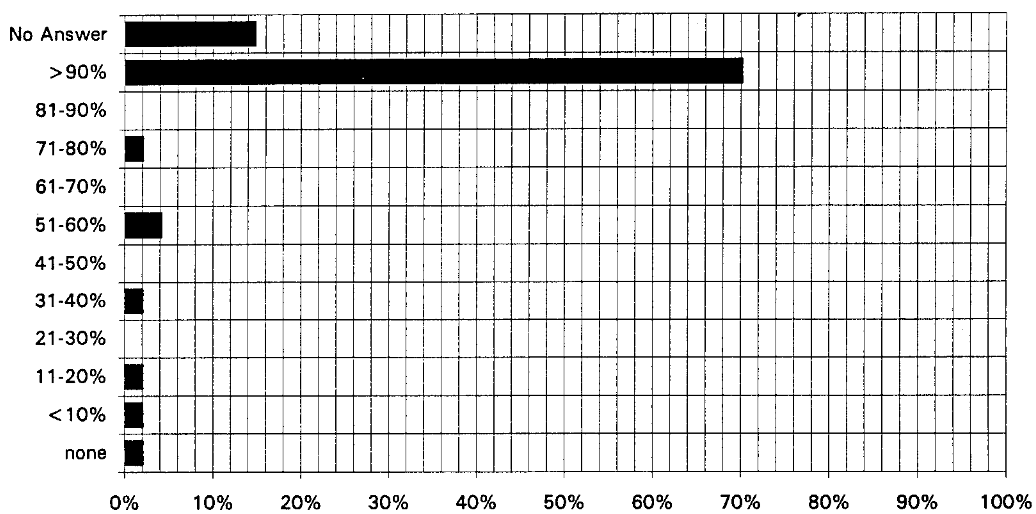
2. Approximately what percent of the propulsion-powered boats that you manufacture in the 12-26 feet range are not equipped with a speedometer?



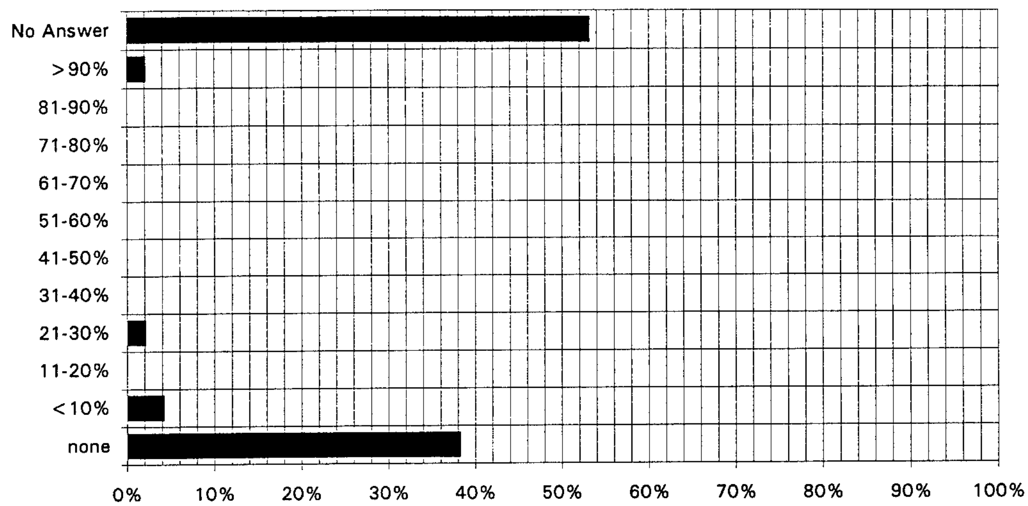
3. Of the boats not equipped with a factory installed speedometer, do you offer an after-market kit that can be installed by the boat owners themselves?



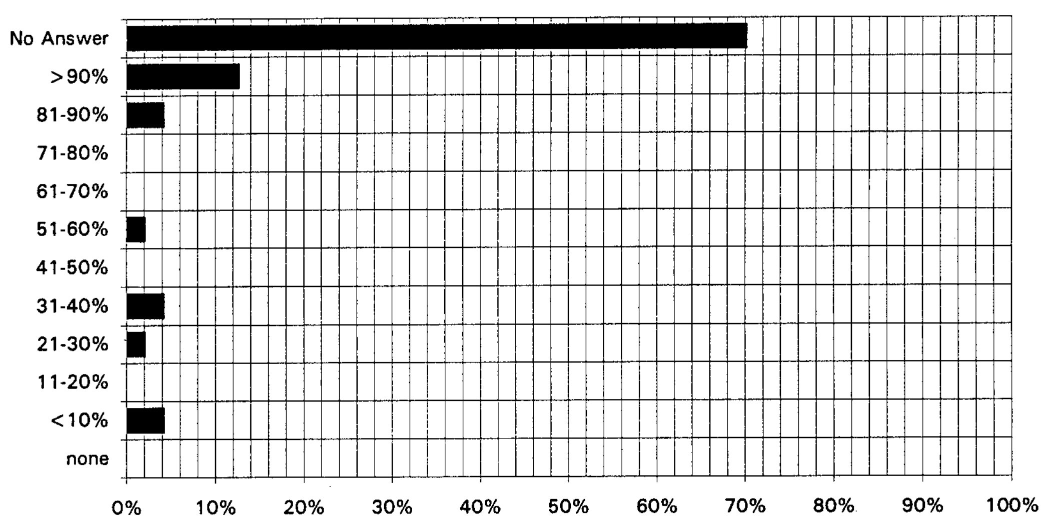
4. Of the propulsion-powered boats you manufacture, ranging from 12 to 26 feet in length, approximately what percentage are V-Hulls?



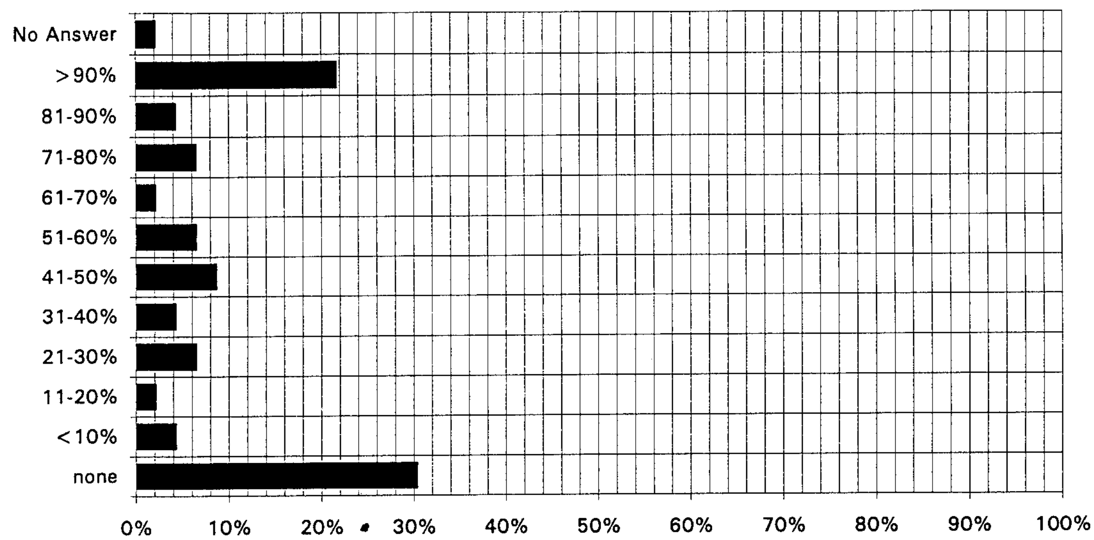
5. Of the propulsion-powered boats you manufacture, ranging from 12 to 26 feet in length, approximately what percentage are Tri-Hulls?



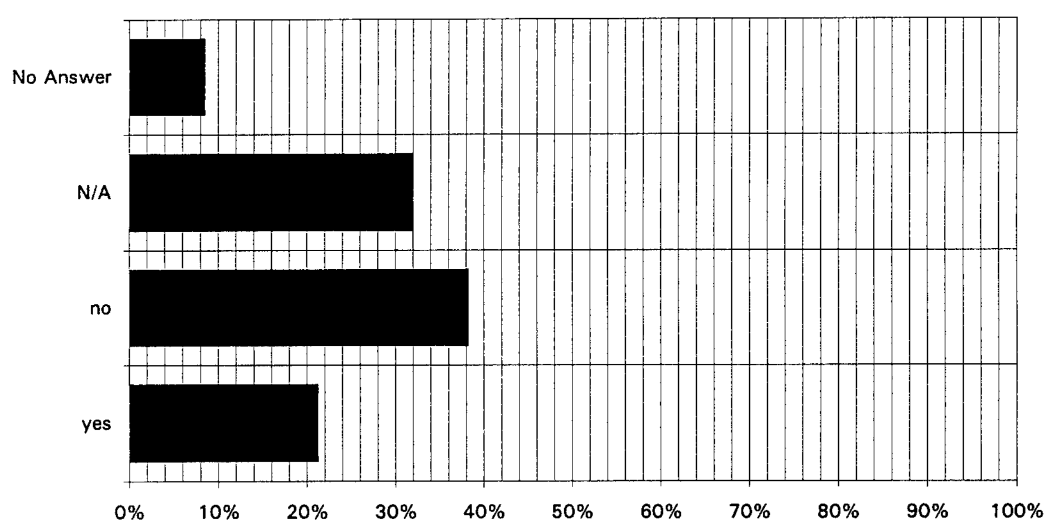
6. Of the propulsion-powered boats you manufacture, ranging from 12 to 26 feet in length, approximately what percentage have a hull other than a V-Hull or Tri-Hull?



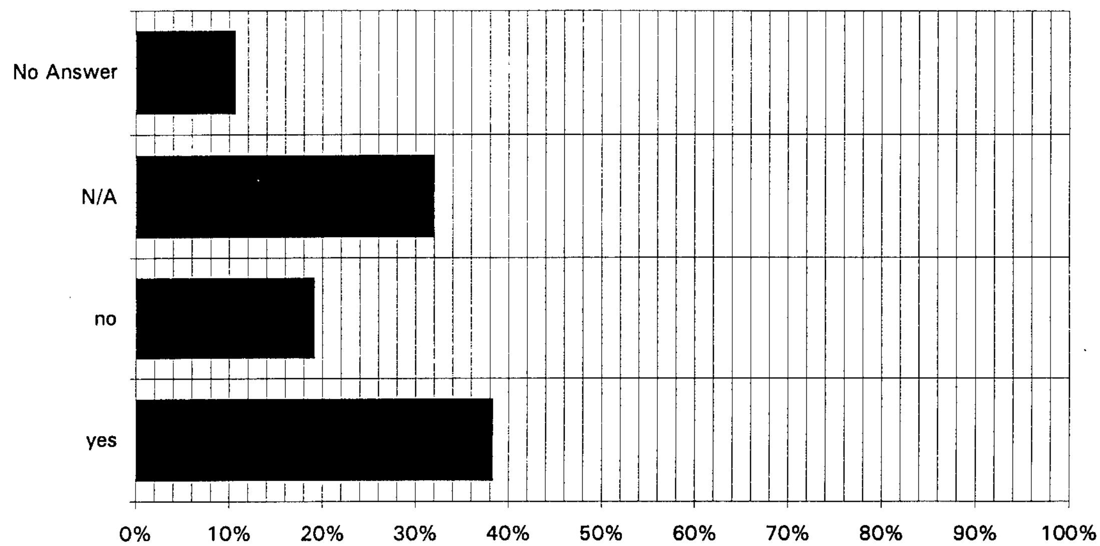
7. Approximately what percentage of the boats you manufacture, ranging from 12 to 26 feet in length, are equipped with engines that have the speedometer pick-up device integral to the engine boot?



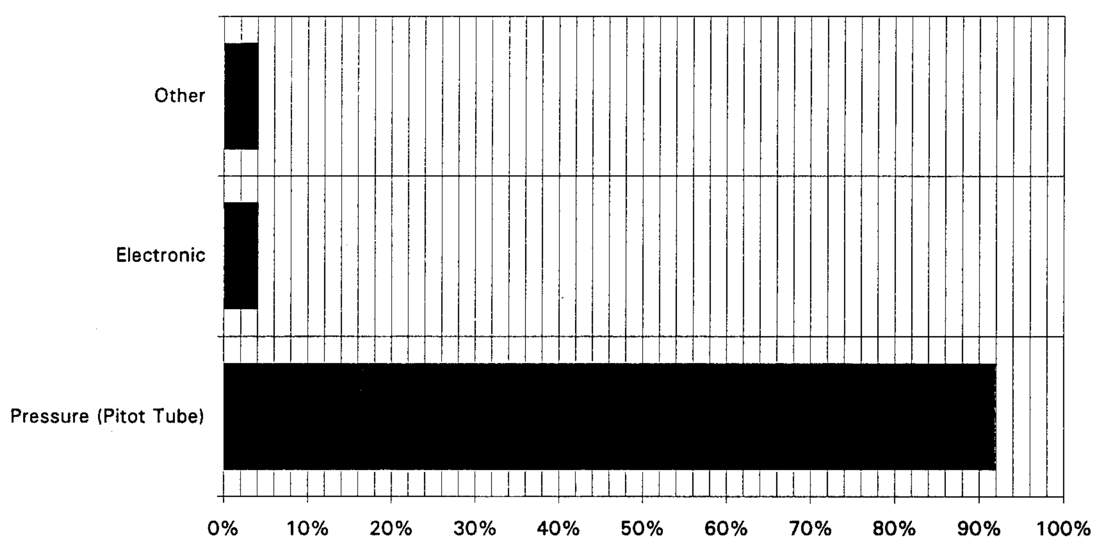
8. Of the boats you manufacture that have the speedometer pick-up located in the engine boot, does the engine manufacturer usually provide or recommend a specific type of speedometer to use?



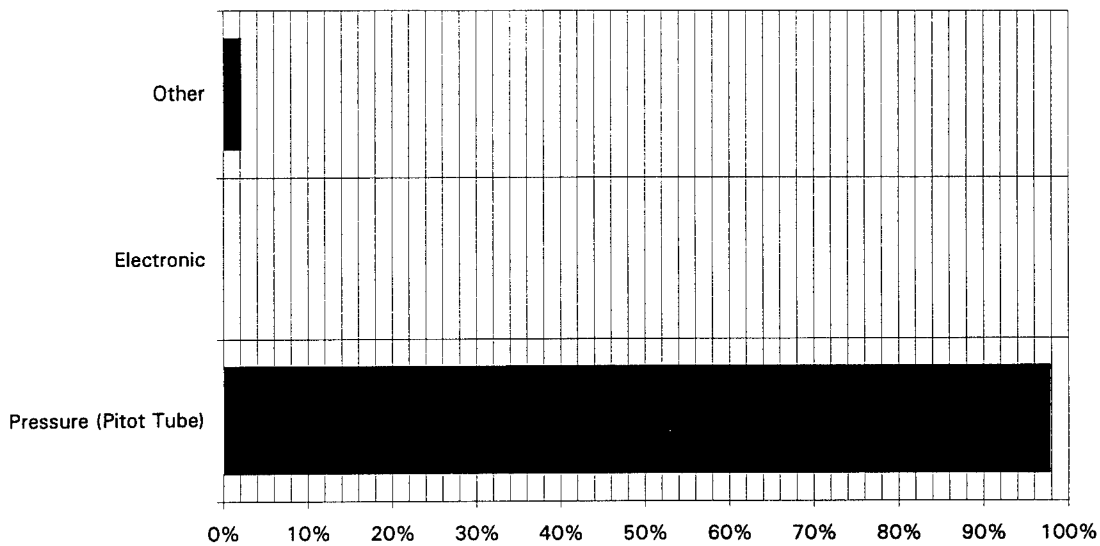
9. Of the boats you manufacture that have the speedometer pick-up located in the engine boot, does the engine manufacturer usually provide installation instructions?



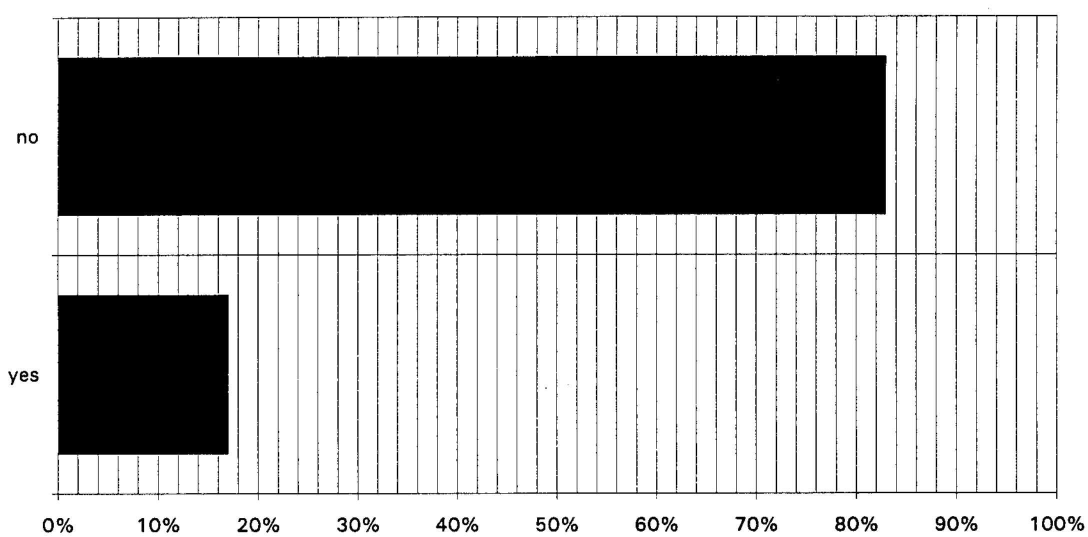
10. Which type of speedometers do you install on your boats ranging from 12 to 26 feet in length?



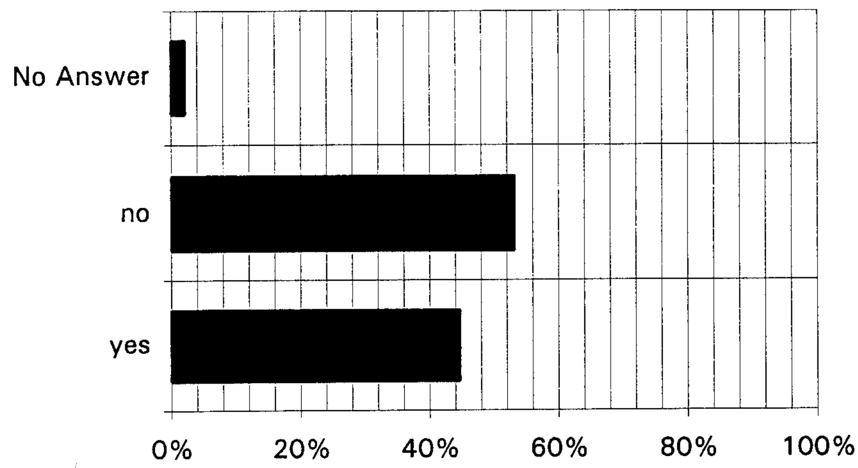
11. Which type of speedometer do you most frequently install on boats you manufacture ranging from 12 to 26 feet in length?



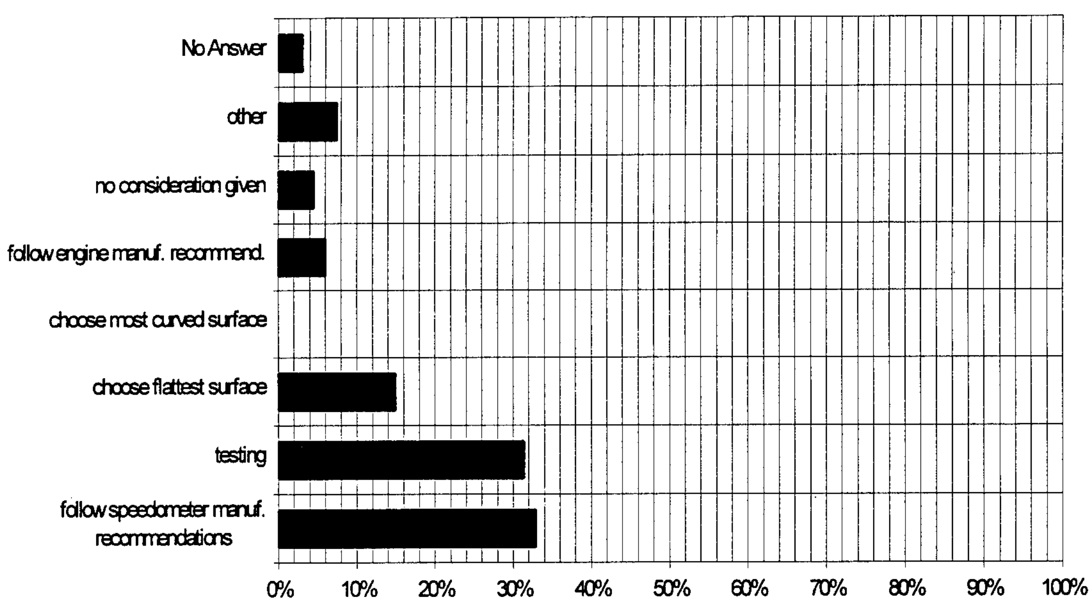
12. Do you require the speedometer manufacturer to provide documentation as to the speedometer's accuracy?



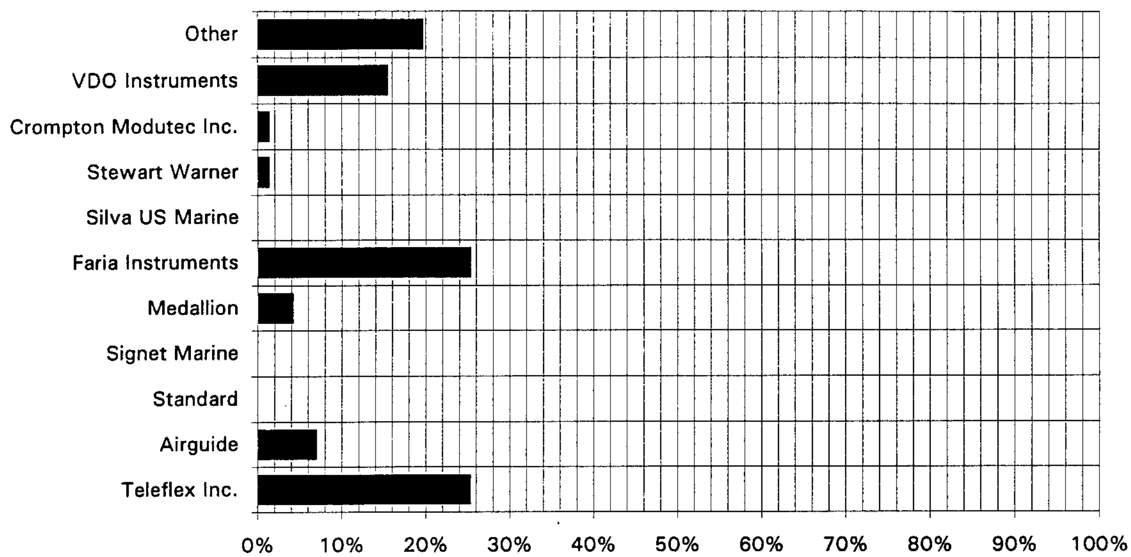
13. Do you make an attempt to verify the accuracy of the speedometers you purchase?



14. Of your boats ranging from 12 to 26 feet in length provided with speedometer pick-ups mounted on the hull, how do you determine the mounting location of the pick-up with respect to the shape of the hull to insure the most accuracy?



15. Do you use speedometer kits (gauges, cables, pick-ups, etc.) on your boats, ranging from 12 to 26 feet in length, that are manufactured by one of the following companies?



2.1 Survey Analysis and Results

The following outlines the results of the survey questions in Section 2.0:

- Almost 90% of the propulsion-powered recreational boat manufacturers surveyed make boats between 12 and 26 ft.
- Greater than 90% of the boats are equipped with a speedometer.
- Approximately 25% of the boats not equipped with a speedometer have after-market kits offered by the boat manufacturer.
- V-hull boats are the most popular style of boat manufactured followed by Tri-hull then hull styles other than V or Tri hulls.
- Thirty percent of the manufacturers do not have the speedometer pick-up device integral to the engine boot. Twenty five percent surveyed said that greater than 90% of their boats do have the speedometer pick-up device integral to the engine boot.
- Of the boats with the speedometer pick-up device integral to the engine boot, most of the engine manufacturers do not recommend a specific speedometer indicator to use but do provide installation instructions.
- Greater than 90% of the manufacturers install Pressure-Pitot type of speedometers.
- More than 80% of the manufacturers surveyed do not require the speedometer manufacturer to provide documentation as to the speedometer's accuracy and most do not attempt to verify the accuracy of the speedometers.
- Most of the manufacturers follow the speedometer manufacturer's recommendations regarding the most accurate speedometer pick-up mounting location on the hull with respect to the shape of the hull. The next largest percentage of manufacturers perform testing to determine the most accurate mounting location.
- Teleflex Inc., Faria Instruments, OMC, VDO Instruments, Airguide, and Medallion manufactured the most widely used speedometer kits used according to the manufacturers surveyed.

Please note that the results of this survey are limited only to the manufacturers which responded and no attempt was made to extrapolate the data to the overall market.

CHAPTER 3

LABORATORY TESTING

3.0 Types Tested

Utilizing the results of the survey outlined in chapter 2, eleven of the most popular pressure-pitot and one paddle wheel type speedometer kits were purchased to be tested in a laboratory environment. The pressure-pitot speedometer kits were labeled P#M# and PW for the paddle wheel. For example, P1M1 refers to the first pitot speedometer kit tested by manufacturer number 1 and P2M2 refers to the second pitot speedometer kit tested by manufacturer number two.

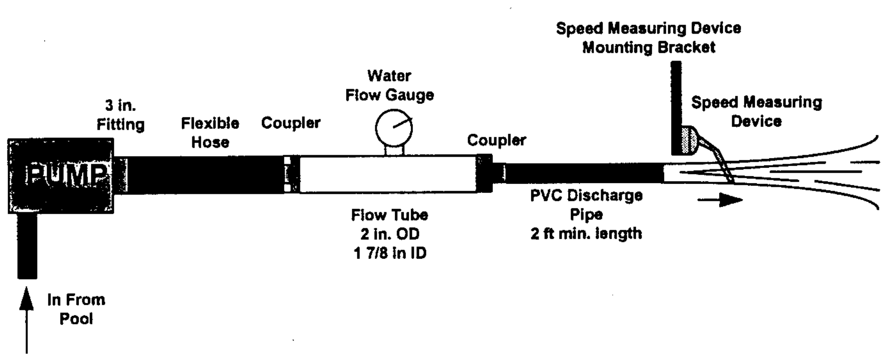
Each of the pressure pitot tube kits contained a pitot tube, length of tubing, and a speed indicator. Kits P1M1,P2M1, P3M1, P4M1, P1M4, P2M4 all utilized the same type of pitot tube. The indicators used during testing were the indicators supplied with each kit. The electronic paddlewheel kit, PW, contained a paddlewheel type sensing device which was wired to an electronic speed indicator.

The theory of operation for the pitot tube and electronic paddlewheel kits involve the following:

> The pitot tube is mounted on the back of the boat with the pitot tube inlet in the water stream. As the boat's speed is increased, water is forced up into the pitot tube which causes a rise in static pressure in the tube which results in movement of the speed indicator needle. The speed indicator is calibrated by the speed indicator manufacturer at several known velocities. Those speed indicators which had speed calibration adjustments were calibrated during laboratory testing.
>
> The electronic paddlewheel pickup is mounted in a similar fashion as the pitot tube with the paddlewheel rotating in the water stream. As the paddlewheel rotates, an electrical signal is sent to the speed indicator via the cable which converts RPM to MPH.

3.1 Laboratory Test Setup

Illustration 3.1-1
Laboratory Test Setup



The equipment used for this test was setup as illustrated in Illustration 3.1-1 and operated in the following manner:

- Water was pumped from the pool reservoir through a calibrated flow meter (275 GPM max. capacity at ±1% accuracy) then through a pipe of reduced diameter, contacted the speed measuring device pickup and discharged back into the pool.
- Water flow rate was measured in gal/min (GPM). Fluid mechanics equations were utilized to determine the proper sized pipes, pump capacity and flow rates to achieve the desired equivalent test speed in MPH.

For example:
The flow rate which corresponded to a speed of 50 MPH was calculated in the following way:

Flow rate equation:

$Q = cVA$ where: Q = flow rate (gallons/min - gpm)
V = Velocity (ft/min)
A = internal pipe area, for a circular pipe, $A = \pi r^2$ (ft^2)
c = Conversion constant

To find the velocity:

$$V = 50\,mph \times \frac{5280\,ft}{1\,mile} \times \frac{1\,h}{60\,min} = 4400\,\frac{ft}{min}$$

Therefore, for simplification, a 1 7/8 in. ID discharge tube and a 1 7/8 in. ID flow tube will be used for the following calculations.

First, calculate the radius of the pipe, r:

$$r = \frac{ID}{2} = \frac{1\frac{7}{8}\,in}{2} \times \frac{1\,ft}{12\,in} = 0.078\,ft$$

Next, calculate the Area of the pipe, A:

$$A = \pi \times r^2 = \pi \times (0.078 ft)^2 = 0.019\,ft^2$$

The flowrate, Q, is calculated in the following way:

$$Q = 4400\,\frac{\cancel{ft}}{min} \times 0.019\,ft^2 = 84.37\,\frac{ft^3}{min}$$

$$Q = 84.37\,\frac{\cancel{ft^3}}{\cancel{min}} \times \frac{7.481\,gal}{1\,\frac{ft^3}{min}} = 631.12\,gpm$$

For a discharge tube smaller than 1 7/8, the continuity equation was utilized:

$$Q1 = Q2$$
$$V_1A_1 = V_2A_2$$

For example, using the data from the example above, if a velocity of 50 MPH was desired at the discharge where the speed measuring pick-up device was mounted, A_1 and A_2 were measured and V_1 was calculated using the continuity equation. V_1 was the velocity at the end of the discharge tube. The corresponding flow rate, Q, was then calculated using the equation:

$$Q = V_1A_1$$

Therefore, a flow rate of 631.12 gpm was required to achieve a velocity of 50 MPH. A graph was developed which correlated the size of the discharge tube, flow rate and MPH which eliminated the need for repeating calculations.

3.2 Laboratory Test Data and Results

Each of the eleven pressure-pitot and the paddle wheel speed measuring devices were installed as shown in Illustration 3.1-1 and exposed to water flows between 10 and 35 MPH as described in section 3.1. The following table outlines the results:

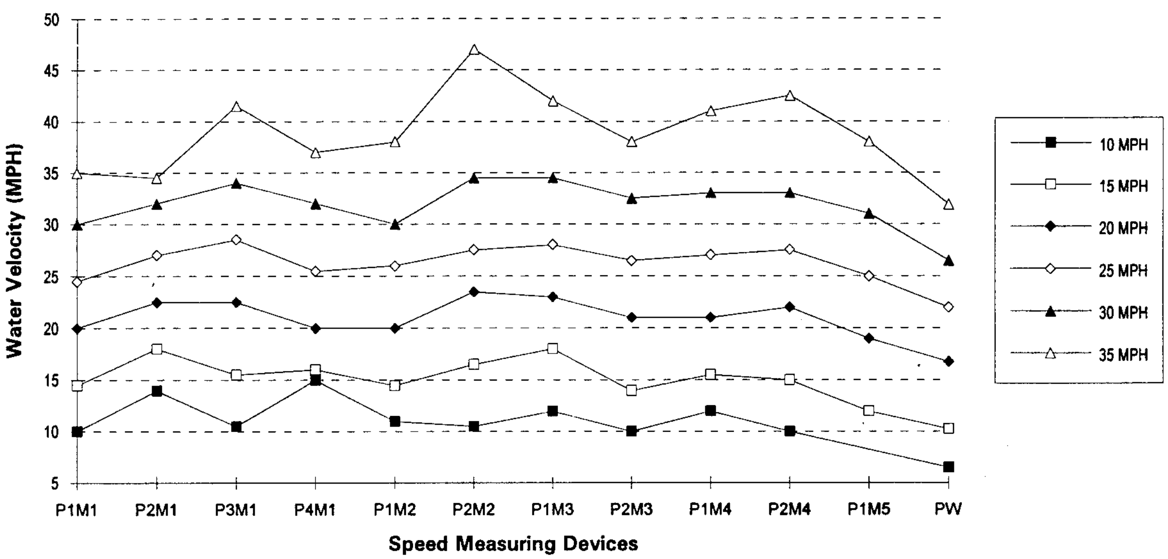
Table 3.2-1
Laboratory Simulated Water Velocities vs. Speed Measuring Device Velocities

Water Velocity	Velocities Recorded for each Speed Measuring Device											
(MPH)	P1M1	P2M1	P3M1	P4M1	P1M2	P2M2	P1M3	P2M3	P1M4	P2M4	P1M5	PW
10	10.0	14.0	10.5	15.0	11.0	10.5	12.0	10.0	12.0	10.0	#N/A	6.5
15	14.5	18.0	15.5	16.0	14.5	16.5	18.0	14.0	15.5	15.0	12.0	10.3
20	20.0	22.5	22.5	20.0	20.0	23.5	23.0	21.0	21.0	22.0	19.0	16.8
25	24.5	27.0	28.5	25.5	26.0	27.5	28.0	26.5	27.0	27.5	25.0	22.0
30	30.0	32.0	34.0	32.0	30.0	34.5	34.5	32.5	33.0	33.0	31.0	26.5
35	35.0	34.5	41.5	37.0	38.0	47.0	42.0	38.0	41.0	42.5	38.0	31.9

The entries in the table which contain "#N/A" represent invalid data points which may have been caused by the velocity being too low or too high for the speed measuring devices speed indicator or for other similar reasons.

Graph 3.2-1 was generated based on Table 3.2-1 which plots "Water Velocity (MPH)" on the Y axis vs. "Speed Measuring Devices" on the X axis.

Graph 3.2-1
Water Velocity for Various Speed Measuring Devices



Graph 3.2-1 is interpreted in the following way:

- The velocities listed on the Y axis represent the laboratory simulated water velocities. Six data points were recorded at velocities of 10,15,20,25,30 and 35 MPH for each speed measuring device. Refer to section 3.1 for information concerning the test setup and how the water velocities were calculated and achieved.
- The X axis contains the coded names for each speed measuring device and which manufacturer they belonged to.
- For example:

If you wish to know how each speed measuring device performed during the 10 MPH test, find the line on the legend of Graph 3.2-1 which represents each mfg.'s data during the 10 MPH test. For this case, this would be the first line with the solid black squares. Next, look at each of the speed measuring devices data points to see how close they were to the 10 MPH horizontal reference line. The distance that the point is from the 10 MPH horizontal reference line is the amount of error in the speedometer indicator reading. Notice that during the 10 MPH test each speed measuring device indicated a velocity of 10 MPH or greater except the paddlewheel which was below 10 MPH.

CHAPTER 4

FIELD TESTING

4.0 Types Tested

Utilizing the laboratory results as outlined in chapter 3, five of the most accurate pressure-pitot and one paddle wheel type speedometer kits were used for testing in the field. The speed measuring devices used were P1M1, P1M2, P1M3, P1M4, P1M5 and PW. See section 3.0 for explanation of these codes.

Two different boats were utilized during testing, a V-Hull and a Tri-Hull. The boat models and manufacturer names will be withheld and will be referred to as V-Hull and Tri-Hull. Boats selected were typical of common boat hull designs and representative of a large percentage of boats in use. The speed measuring devices were mounted to the lower transom area of each boat using suction cups designed for this purpose. Testing was performed on a private lake under controlled conditions.

Three methods were used during testing to calculate boat speed. The first method was the speed as indicated on each speed measuring device's speed indicator. The second method utilized a hand held RADAR gun. The third method involved time averaging where the boat's speed was calculated by recording the time for the boat to travel between two fixed buoys which were 265 ft. apart. Many test runs were conducted and the data recorded for each speed measuring device was compared to the average of the speed indicated by the RADAR gun and the Timing method which was considered the "Control" speed.

4.1 Determining Most Accurate Location

The purpose of the first test performed was to determine the most accurate mounting location for the six speed measuring devices. This was determined by comparing the performance of each to the RADAR and Timing methods. Two pressure pitot speed measuring devices mounted on the lower transom area of each boat, 18 in. from the boat centerline and 10 in from the transom edge, were tested at 20, 30 and 40 MPH. Due to the boat's symmetry, both the port and starboard mounting locations were utilized to minimize the number of on-water test runs required. Test runs were conducted and the data for each speed measuring device was compared to the RADAR/Timing method average to determine the most accurate mounting location for mounting the other speed measuring devices for subsequent testing. Illustration 4.1-1, Tables 4.1-1, 4.1-2, 4.1-3 and 4.1-4 and Graphs 4.1-1 and 4.1-2 show and compare the data collected to determine the most accurate mounting location for both the V-Hull and Tri-Hull.

For the V-hull, Model P1M1 was used at both the 18 in. from centerline and 10 in. from transom edge positions. For the Tri-hull, Model P1M4 was used 10 in. from the transom edge and the boat's built-in native speedometer was used as it was already installed 18 in. from the boat's centerline. The boat's native speedometer was manufactured by the same manufacturer and incorporated the same pickup as Model P1M4.

Illustration 4.1-1
Speed Measuring Device Mounting Locations

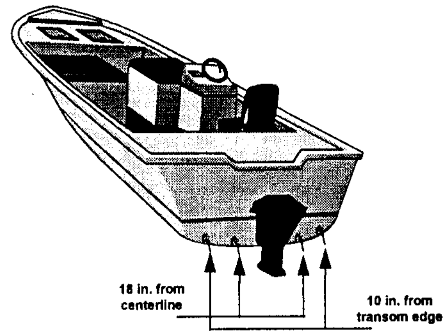


Table 4.1-1
Data for V-Hull, 18 in. from Boat Centerline

Boat Speed (MPH)	Test Specimen	Test Specimen Speed (MPH)	RADAR (MPH)	Timing (Sec)	Timing (MPH)	Pitot Press. (PSI)	RPM
20.0	P1M1	22.5	22.3	8.1	22.3	6.5	3000
30.0	P1M1	31.5	30.7	5.9	30.7	13.0	3500
40.0	P1M1	41.0	39.5	4.6	39.6	21.2	4100

Table 4.1-2
Data for V-Hull, 10 in. from Transom Edge

Boat Speed (MPH)	Test Specimen Model	Test Specimen Speed (MPH)	RADAR (MPH)	Timing (Sec)	Timing (MPH)	Pitot Press. (PSI)	RPM
20.0	P1M1	22.0	21.5	8.4	21.4	6.5	3000
30.0	P1M1	31.0	29.5	6.2	29.2	12.5	3500
40.0	P1M1	41.0	39.5	4.5	39.9	22.0	4100

Graph 4.1-1
V-Hull Data from Tables 4.1-1 and 4.1-2.

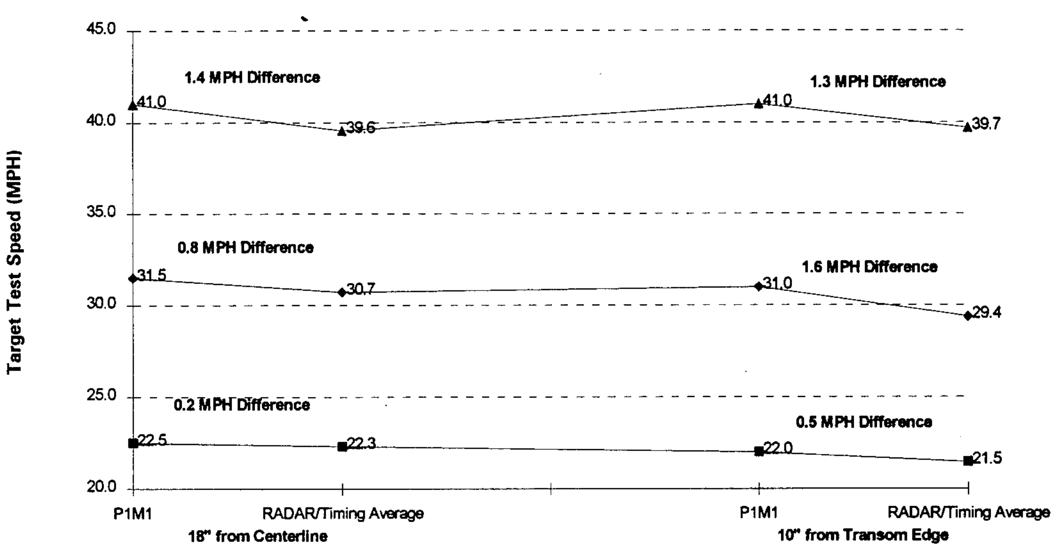


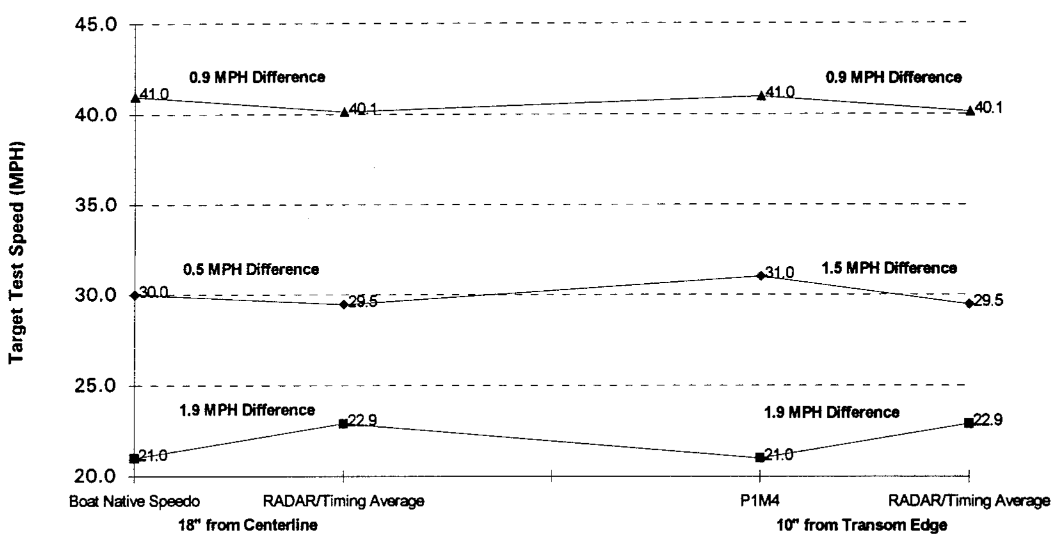
Table 4.1-3
Data for Tri-Hull, 18 in. from Boat Centerline

Boat Speed (MPH)	Test Specimen	Test Specimen Speed (MPH)	RADAR (MPH)	Timing (Sec)	Timing (MPH)	Pitot Press. (PSI)	RPM
20.0	Medallion Unit on Boat	21.0	22.7	7.8	23.1	2.1	2500
30.0	Medallion Unit on Boat	30.0	29.4	6.1	29.5	4.2	3000
40.0	Medallion Unit on Boat	41.0	40.5	4.5	39.8	7.8	3800

Table 4.1-4
Data for Tri-Hull, 10 in. from Transom Edge

Boat Speed (MPH)	Test Specimen Model	Test Specimen Speed (MPH)	RADAR (MPH)	Timing (Sec)	Timing (MPH)	Pitot Press. (PSI)	RPM
20.0	P1M4	21.0	22.7	7.8	23.1	5.5	2500
30.0	P1M4	31.0	29.4	6.1	29.5	11.9	3000
40.0	P1M4	41.0	40.5	4.5	39.8	21.2	3800

Graph 4.1-2
Utilizing Data for Tri-Hull from Tables 4.1-3 and 4.1-4.



Graphs 4.1-1 and 4.1-2 are interpreted in the following way:

- The velocities listed on the Y axis represent the targeted boat speed during each test run. Three test runs were made at 20, 30 and 40 MPH respectively.
- The left half of the X axis contains test data for the speed measuring device mounted 18 in. from the boat's centerline and the right half contains data for mounted 10 in. from the transom edge as illustrated in Illustration 4.1-1.
- Each half of Graph 4.1-1 shows velocity data for the speed measuring device and the average of the velocities recorded for the RADAR and Timing methods which are all outlined in Tables 4.1-1, 4.1-2, 4.1-3 and 4.1-4.
- The RADAR and Timing method velocities were averaged to obtain a reference or control velocity which was compared to the speed measuring device velocity at each mounting location.

- Graphs 4.1-1 and 4.1-2 shows a lower speed difference between the speed measuring device and the RADAR/Timing method average when the speed measuring device was mounted 18 in. from the boat's centerline.
- Therefore, the rest of the speed measuring devices were tested at 18 in. from the centerline on either side of the boat for both the V-hull and the Tri-hull.

4.2 Field Test Data at Most Accurate Location

Five pitot, P1M1, P1M2, P1M3, P1M4, P1M5 and one paddle wheel, PW, speed measuring devices were mounted 18 in. from the boat's centerline on both the V-Hull and the Tri-Hull and were tested at 20 ,30, and 40 MPH as outlined in the following Table 4.2-1 and 4.2-2:

TABLE 4.2-1
Velocities Recorded on the V-Hull for each Speed Measuring Device

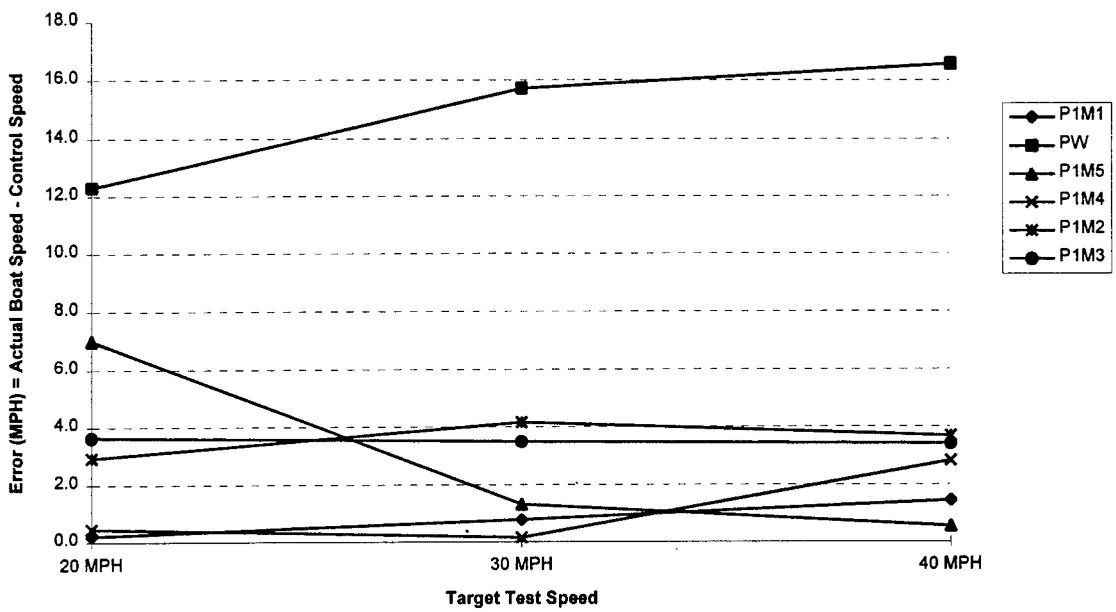
Target Boat	TEST RUN 1				TEST RUN 2				TEST RUN 3			TEST RUN 4		
Speed	P1M1	PW	RADAR	TIMING	P1M2	P1M4	RADAR	TIMING	P1M5	RADAR	TIMING	P1M3	RADAR	TIMING
20 MPH	22.5	10.0	22.3	22.3	19.0	16.5	19.8	19.1	15.0	21.5	22.5	18.0	21.7	21.6
30 MPH	31.5	15.0	30.7	30.7	30.0	26.0	30.2	30.1	29.0	30.7	29.9	34.0	30.6	30.4
40 MPH	41.0	23.0	39.5	39.6	42.0	35.5	39.0	39.4	39.0	39.5	39.6	44.0	40.2	41.0

TABLE 4.2-2
Velocities Recorded on the Tri-Hull for each Speed Measuring Device

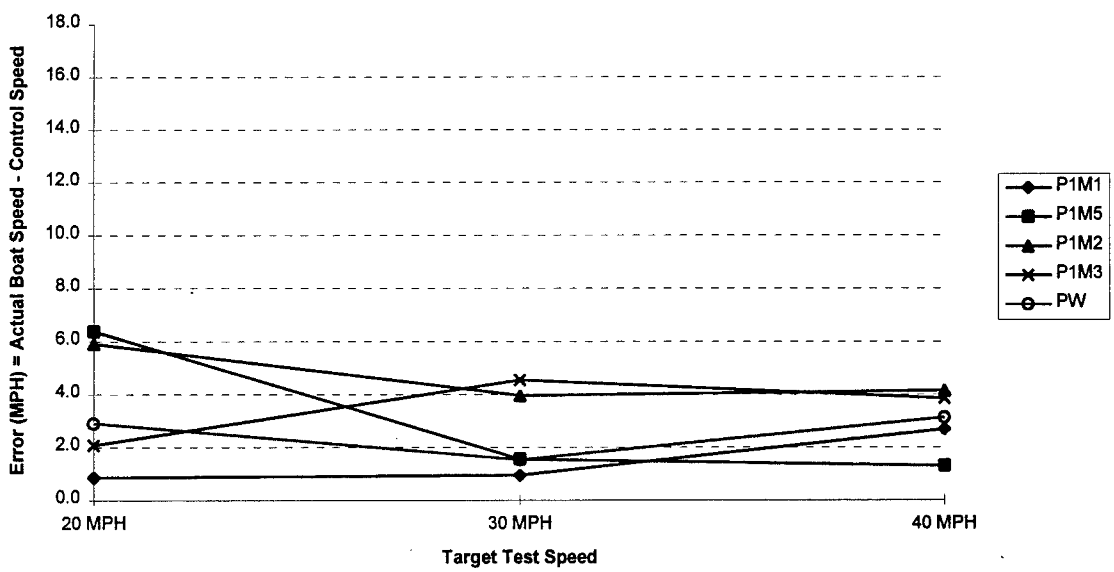
Target Boat	TEST RUN 1				TEST RUN 2				TEST RUN 3		
Speed	P1M1	P1M5	RADAR	TIMING	P1M2	P1M3	RADAR	TIMING	PW	RADAR	TIMING
20 MPH	19.5	14.0	20.6	20.1	17.0	25.0	22.7	23.1	20.0	22.7	23.1
30 MPH	31.5	29.0	30.5	30.6	25.5	34.0	29.4	29.5	31.0	29.4	29.5
40 MPH	42.5	39.0	39.5	40.1	36.0	44.0	40.5	39.8	37.0	40.5	39.8

Graphs 4.2-1 and 4.2-2 were generated based on Tables 4.2-1 and 4.2-2 respectively which plot "Error (MPH)" on the Y axis vs. "Speed Measuring Devices" on the X axis.

Graph 4.2-1
V-Hull, Error in MPH vs. Target Test Speed for each Speed Measuring Device



Graph 4.2-2
Tri-Hull, Error in MPH vs. Target Test Speed for each Speed Measuring Device



Graphs 4.2-1 and 4.2-2 are interpreted in the following way:

- The values listed on the Y axis represent the number of MPH that each speed measuring device differed from the control speed which was the average of the velocities recorded using RADAR and the Timing Method.
- The X axis represents the Target Boat Speeds and each line represents the coded names for each speed measuring device and which manufacturer they belonged to.
- For example:

If you wish to know which speed measuring device was most accurate when compared to the average of the RADAR and the Timing methods, find the line which has the least amount of error or the line that was closest to the X-axis.

CHAPTER 5

RESULTS

5.0 Summary of Results

The following sections will briefly summarize all of the results obtained in the document.

5.1 Survey Summary

Two hundred and twenty two surveys consisting of 15 questions were sent to various boat manufacturers and various manufacturers of after-market speed measuring devices of which 56 were returned. Consult chapter 2 for the survey questions posed to the manufactures and their responses. An overview of the survey results are as follows:

- Almost 90% of the propulsion-powered recreational boat manufacturers surveyed make boats between 12 and 26 ft.
- Greater than 90% of the boats are equipped with a speedometer.
- Approximately 25% of the boats not equipped with a speedometer offer after-market kits to be installed by the boat owner.
- V-hull boats are the most popular style of boat manufactured followed by Tri-hull then hull styles other than V or Tri hulls.
- 30% of the manufacturers do not have the speedometer pick-up device integral to the engine boot. 25% surveyed said that greater than 90% of their boats do have the speedometer pick-up device integral to the engine boot.
- Of the boats with the speedometer pick-up device integral to the engine boot, most of the engine manufacturers do not recommend a specific speedometer to use but do provide installation instructions.
- Greater than 90% of the manufacturers install Pressure-Pitot type of speedometers.
- More than 80% of the manufacturers do not require the speedometer manufacturer to provide documentation as to the speedometer's accuracy and most do not attempt to verify the accuracy of the speedometers.
- Most of the manufacturers follow the speedometer manufacturer's recommendations regarding the most accurate speedometer pick-up mounting location on the hull with respect to the shape of the hull. The next largest percentage of manufacturers perform testing to determine the most accurate mounting location.
- Teleflex Inc., Faria Instruments, OMC, VDO Instruments, Airguide, and Medallion manufactured the most widely used speedometer kits used according to the manufacturers surveyed.

5.2 Lab Test Summary

Utilizing the results of the survey outlined in chapter 2, eleven of the most popular pressure-pitot and one paddle wheel type speedometer kits were purchased to be tested in a laboratory environment. Consult Chapter 3 for a description of the test setup. Each speed measuring device was exposed to a calculated water velocity and the velocity was recorded on the speed indicator of each speed measuring device. The speed indicator velocities were compared to the calculated water velocities for the following reasons:

- To verify accurate calibration of each speed measuring device
- Five of the most accurate pitot and one electronic paddle wheel speed measuring devices tested in the lab were used for Field testing.

The five speed measuring devices selected for field testing were: P1M1, P1M2, P1M3, P1M4, P1M5, and PW. See Chapter 3 for an explanation of the speed measuring device code names.

5.3 Field Test Summary

Utilizing the laboratory results as outlined in chapter 3, five of the most accurate pressure-pitot and one paddle wheel type speedometer kits were used for testing in the field. The speed measuring devices used were P1M1, P1M2, P1M3, P1M4, P1M5 and PW. See section 3.0 for explanation of these codes.

Two different boats were utilized during testing, a V-Hull and a Tri-Hull. The boat models and manufacturer names will be withheld and will be referred to as V-Hull and Tri-Hull. Boats selected were typical of common boat hull designs and representative of a large percentage of boats in use. The speed measuring devices were mounted to the lower transom area of each boat using suction cups designed for this purpose. Testing was performed on a private lake under controlled conditions.

Three methods were used during testing to calculate boat speed. The first method was the speed as indicated on each speed measuring device's speed indicator. The second method utilized a hand held RADAR gun. The third method involved time averaging where the boat's speed was calculated by recording the time for the boat to travel between two fixed buoys which were 265 ft. apart. Many test runs were conducted and the data recorded for each speed measuring device was compared to the average of the speed indicated by the RADAR gun and the Timing method which was considered the "Control" speed.

The purpose of the first test performed in the field was to determine the most accurate mounting location for the speed measuring devices which was 18 in. from the boats centerline on either side of the boat.

The purpose of the second test performed was to compare the performance of each speed measuring device with each device mounted at the most accurate mounting location which was 18 in. from the boat's centerline on either side of the boat. The pitot speed measuring devices were more accurate than the electronic paddle wheel for the V-Hull but had similar results for the Tri-Hull. Certain pitot manufacturers models were more accurate than the other pitot manufacturers.

For the V-Hull boat, the pitot speed measuring devices were all within 7 MPH of the control velocity. The control velocity was the average between the RADAR and Timing methods for each test run conducted at 20, 30, and 40 MPH. The electronic paddle wheel's velocities were all greater than 12 MPH of the control velocity.

The same test runs were conducted on the Tri-Hull boat in which the pitot speed measuring devices were all within 7 MPH of the control velocity. Again, the electronic paddle wheel's velocities were all within 4 MPH of the control velocity.

The speed measuring devices proved slightly more accurate on the V-Hull than the Tri-Hull boats.

REFERENCES

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